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BODY FORM IN Homo sapiens: A STUDY OF FIVE ANTHROPOMETRIC RATIOS ON WHITE BOYS FIFTEEN YEARS OF AGE[1]

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This investigation, in different ways, is related to a considerable amount of previously reported research on growth.[2] Its sample is the same as was utilized in an earlier study of body size (15). Its ratios and methods of analysis parallel those employed in studies of body form[3] on younger children (12, 13, 14). Its problem makes it part of the large literature pertaining to human form (19, 1) and the form of biologic organisms generally (18, 3).

PURPOSE

The overall objective is to depict 5 aspects of body form (a) on a sample of 15-year-old public school boys, (b) using metrical data, and (c) giving consideration to problems of reliability, central tendency, variability, and interrelationship. Of the 5 continua studied, 3 fall in the slender-to-stocky class, *i.e.*, they portray gradations in ratio of girth to length for the upper extremity, lower extremity, and body stem respectively. The 2 other continua quantify form components of the regional-predominance variety. These express the percentage relation of the shoulder width to hip width, and girth of thorax to girth of abdomen.

Specific aims of the study are:

1. To determine reliabilities for the 5 ratios on boys 15 years of age. Investigation is made of the consistency of ratios derived

[1]Research financed in part through a special grant from the Graduate School, University of Oregon.

[2]Growth, as used here, has the broad morphologic connotation recognized in the founding of this journal. It encompasses changes during the life history of an organism in the form, size, number, kind, location, and texture of its somatic constituents.

[3]Various investigations have made synonymous use of the terms form (4), build (8), physique (7), type (2), constitution (20), somatotype (17), proportions (6), and shape (10).

from 2 procedures of data collection, collection by anthropometrists working singly and as two-man teams.

2. To obtain the arithmetic mean for each ratio on a 1950 sample of white public school boys aged 15 years residing in west-central Oregon. Also, for those ratios on which there are available means from other samples of North American boys representing this age, to make central tendency comparisons.

3. To describe the variability of each ratio, employing both the standard deviation and percentile-distance approaches. The latter approach is used to construct tentative "frames of reference" covering the 5 aspects of form on white boys 15 years of age.

4. To discover interrelationships among the ratios. One interest here is to determine whether the association between any 2 of the ratios is sufficiently high that practically as much information about body form can be secured from one as from both.

Subjects

The subjects are 102 white boys between the ages of 14 years 9 months and 15 years 3 months. Except for the rejection of 5 individuals exhibiting varying forms of gross body pathology, they represent a random sample of boys this age in attendance during the first half of 1950 at the three junior high schools of Public School District No. 4, Eugene, Oregon.[4]

All of the boys were born in North America and practically all were of northwest European ancestry. Forty-six per cent were born in Oregon, 10 per cent in Washington or Idaho, and 5 per cent in California or Nevada. Birthplace for the remaining 39 per cent was scattered, with 4 boys only born east of the Mississippi River. The mean period of residence in Oregon, for the entire sample, was 10 years 4 months.

Basic Measurements

Computation of the ratios necessitated measurements for 9 dimensions of the body. Detailed description of the anthropometric technique used in obtaining these measurements has been presented in an earlier publication (15). Beyond reference to the accessibility of this detailed statement, it will suffice to list a succinct identification of each measurement.

[4]Grateful acknowledgement is made to Superintendent Clarence Hines, Doctor Madeline Marr, and the personnel of the junior high schools for their full cooperation.

Arm girth. Maximum circumference of the left arm in the region approximately half-way between the acromion and olecranon processes.

Chest girth. Circumference of the thorax, at the level of the xiphisternal junction, under conditions of normal respiration.

Abdomen girth. Trunk circumference, during normal posture, at the level of the umbilicus. In instances of umbilical protrusion, the measurement was taken immediately above the umbilicus.

Leg girth. Maximum circumference of the left leg in the region of the calf.

Upper limb length. Greatest distance, on the left side, from the lateral border of the acromion to the distal tip of the middle finger.

Stem length. Distance from the vertex to the upper surface of a wooden bench on which the subject assumed an erect sitting position.

Lower limb length. Stature minus stem length, *i.e.*, the maximum vertical distance from the most inferior plane of the ischia to the plantar surface of the feet.

Shoulder width. Transverse distance between the most lateral points of the acromion processes, with the shoulder region in normal position.

Hip width. Transverse distance between the lateralmost projections of the crests of the ilia under conditions of firm pressure on the overlying tissues.

The subjects were scheduled for measurement individually. Prior to measurement, each boy was briefed regarding the general procedure and the approximate time needed for completion of the examination. Measurements were taken with the subject wearing only his shorts, and at no time was a measuring instrument read where the conditions were considered likely to yield morphologically unsound results. Examples of the latter include chest expansion or breath-holding during the taking of chest girth, contraction of the biceps or triceps muscles during the taking of arm girth, restraint or protrusion of the abdomen in abdomen girth, and elevation of the shoulders in shoulder width.

Four anthropometrists—conveniently designated by the letters T, S, N and P[5]—measured each boy. All were trained in the anthropometric methods used in the child growth research program at the University of Oregon. T and S worked as one team, N and P as a separate team. The procedure may be illustrated as follows: Subject

[5]Peter Trim, Paul Sherbina, Edward Newcomer and Everett Peery.

A first went to team T-S, T took the full series of measurements while S acted as assistant and recorder, then S took the series while T acted as assistant and recorder. In instances where T and S did not obtain close agreement, both made additional measurements.[6] The "close agreement" criteria were derived from earlier investigations of reliability (9, 11). Specifically, they were agreements within 0.1 cm. for leg girth and hip width, 0.2 cm. for stature and arm girth, and 0.4 cm. for other measurements.

When examination by T-S was completed, Subject A passed on to N-P. This team worked independently, following the same procedure as team T-S.

The Ratios

As indicated previously, the 5 ratios selected for study include 3 that portray the stockiness of major body segments and 2 that depict the relationships between upper and lower aspects of the trunk. The body segment group consists of the following:

$$\text{Upper extremity ratio} = \frac{\text{Arm girth}}{\text{Upper limb length}} \times 100$$

$$\text{Body stem ratio} = \frac{\text{Chest girth}}{\text{Stem length}} \times 100$$

$$\text{Lower extremity ratio} = \frac{\text{Leg girth}}{\text{Lower limb length}} \times 100$$

Those representing the relative predominance of trunk regions are:

$$\text{Shoulders-pelvis ratio} = \frac{\text{Shoulder width}}{\text{Hip width}} \times 100$$

$$\text{Thorax-abdomen ratio} = \frac{\text{Chest girth}}{\text{Abdomen girth}} \times 100$$

It will be noted that the quotient from each division is multiplied by 100, following customary practice, in order to express each ratio as a percentage.

[6]Always 4 measurements were made for chest girth and abdomen girth.

Reliability Findings

The procedure in measuring the subjects afforded 2 types of records for the study of reliability. On the one hand, ratios could be derived from the records of a single anthropometrist. On the other hand, ratios could be secured from the composite measures of a two-man team. Since it was desired to compare reliabilities for the 2 methods of data collection, ratios of both types were obtained.

With each of the 5 aspects of form, the manner of preparation for reliability analysis was the same. Two series of values for each method of data collection were computed. For the "single record" method, these separate series were calculated from the initial measurements taken on each boy by anthropometrists T and N. For the "two-man team" method, computation of the paired series was based upon the composite measures for each boy from the T-S and N-P teams. It will be recalled that the composite measures were in some instances the average of 4 records and in other instances (where the criterion differences were not exceeded) the average of 2 records.

Reliability was studied through the medium of the Pearson product-moment method of correlation. Analysing for each of the 5 ratios under both procedures of data collection, 10 coefficients were computed. Table 1, column 2, gives the r's secured from correlating the 102 pairs of ratio values derived from the first measurements taken by T and the first measurements taken by N. Table 1, column 3, presents comparable r's obtained from correlating the paired series based upon the composite measures fo each two-man team. Findings are as follows:

1. Derived from single measurement data, the 5 body form ratios yield coefficients of reliability for 15-year-old boys ranging from .85 to slightly less than .99. Using the composite measures of the two-man teams, the ratio reliabilities are systematically higher and all above $r = .95$.

2. The reliability coefficients are higher for the 2 ratios depicting form of the extremities than for the 2 portraying form of the trunk. This accords with expectation from body size reliabilities: measurement consistency is known to be higher for the 4 dimensions utilized in the limb ratios than for shoulder width, chest girth, and abdomen girth (9, 11, 15).

3. Compared with the "single record" reliabilities, the "composite

TABLE 1

RELIABILITY STATISTICS FOR 5 ANTHROPOMETRIC RATIOS ON BOYS 15 YEARS OF AGE: COEFFICIENTS FOR EACH RATIO OBTAINED BY 2 METHODS, AND PER CENT IMPROVEMENT IN RELIABILITY WITH THE USE OF TEAM RECORDS

Ratio	N	Type of Basic Measures: Single r*	Composite r**	Increase in Consistency %
$\frac{\text{Leg Girth} \times 100}{\text{Lower Limb Length}}$	102	.986	.997	8.9
$\frac{\text{Arm Girth} \times 100}{\text{Upper Limb Length}}$	102	.979	.989	5.6
$\frac{\text{Chest Girth} \times 100}{\text{Stem Length}}$	102	.963	.981	7.5
$\frac{\text{Shoulder Width} \times 100}{\text{Hip Width}}$	102	.908	.976	20.1
$\frac{\text{Chest Girth} \times 100}{\text{Abdomen Girth}}$	102	.850	.956	23.3

*Derived from the initial measurements of anthropometrists T and N. Corresponding r's based upon the initial measurements taken by anthropometrists S and P are .988, .976, .956, .910 and .861 respectively.

**Derived from the composite records of the T-S team and the N-P team.

record" reliabilities represent improvements of 5 to 10 per cent for 3 of the ratios, and of more than 20 per cent for the 2 others. Certainly in any study calling for the body form characterization of individuals, an increase in ratio consistency as large as 20 per cent must be considered ample grounds for taking the additional time necessary to obtain team measures.

CENTRAL TENDENCY FINDINGS

Throughout the remainder of the paper, body form analyses are based upon all of the measurement data obtained on each subject. For example, the ratio values used to represent the slender-to-stocky continuum for the upper extremity are derived from averages of the records of the 4 anthropometrists for arm girth and upper limb length.

Two measures of central tendency were employed, the arithmetic mean and the median. The mean for each of the 5 series of ratio values is given in Table 2, column 1. The adjacent column lists the medians. Comparison of the 2 sets of figures reveals the finding of somewhat higher means than medians for the 3 ratios representing

form continua of the slender-to-stocky variety. This is in harmony with findings obtained for the same ratios at ages 7 and 8 years on Iowa boys (13) and at ages 7 and 10 years on Oregon boys (12). Application of a test of skewness to the data of the present study showed: (a) the suggestion of asymmetry in the distribution for the lower limb ratio is not reliable statistically, and (b) the distributions for the upper limb and body stem ratios are skewed significantly[7] to the right.

A generalized statement of central tendency findings is as follows: For the sample of 15-year-old white boys under study,

1. Arm circumference approximates 34 per cent (median) to 35 per cent (mean) of the length from acromion to dactylion.
2. Stem circumference at the xiphoid level approximates 90 per cent (median) to 91 per cent (mean) of stem length.
3. Calf girth is slightly less than 43 per cent (mean and median) of lower limb length (stature minus stem length).
4. Biacromial width of shoulders is roughly 139 per cent (mean and median) of bi-iliocristal width of hips.
5. Chest girth at xiphoid approximates 106 per cent of abdomen girth at umbilicus. While the somewhat smaller mean than median suggests skewness to the left, statistical evaluation does not warrant rejection of the hypothesis that this ratio is distributed symmetrically.

Comparative means are available for 2 of the 5 ratios. Gray and Ayres (5) studied bi-iliocristal diameter $\times$ 100/biacromial diameter on 362 white private school boys 15 years of age. While this ratio is the reverse of that used in the present study, it is a simple matter to take the reciprocal of the reported mean. Compared with the appropriate mean from Table 2 (138.9), the adjusted mean from Gray and Ayres (136.0) is lower. The difference is significant statistically at the 1 per cent level of confidence and, in view of the fact the descriptions of anthropometric technique for the 2 studies are detailed and equivalent (5, p. 27; 15, p. 27), appear to have morphologic validity.

On a sample of 108 New York City boys of native-born white parentage, Schwartz, Britten and Thompson (16) obtained a mean ratio of 114.6 for chest girth in percentage of abdomen girth. The large discrepancy between this mean and the comparable mean in

[7]At the 1 per cent and 2 per cent levels of confidence, respectively.

TABLE 2

CENTRAL TENDENCY AND VARIABILITY STATISTICS FOR 5 ANTHROPOMETRIC RATIOS ON BOYS 15 YEARS OF AGE: SAMPLE CONSISTS OF 102 WHITE PUBLIC SCHOOL BOYS MEASURED DURING THE SPRING OF 1950 AT EUGENE, OREGON

Ratio	Mean	Median	Standard Deviation	Range
$\frac{\text{Arm Girth} \times 100}{\text{Upper Limb Length}}$	34.9	34.2	3.65	28.0— 46.6
$\frac{\text{Chest Girth} \times 100}{\text{Stem Length}}$	91.1	90.1	5.73	81.3—110.1
$\frac{\text{Leg Girth} \times 100}{\text{Lower Limb Length}}$	42.8	42.5	3.59	35.7— 52.3
$\frac{\text{Shoulder Width} \times 100}{\text{Hip Width}}$	138.9	139.1	7.69	122.6—157.2
$\frac{\text{Chest Girth} \times 100}{\text{Abdomen Girth}}$	105.6	106.0	4.90	92.8—116.9

Table 2 seems to arise mainly from differences in methodology. Schwartz, Britten and Thompson measured chest girth at the level of the nipples, and took the average of records "at total inspiration" and "at total expiration." Their abdominal dimension was defined as "circumference of the waist at the umbilicus." Compared with the procedures of the present study, the latter probably came closer to being a measurement of minimum girth of the lower trunk, while the former represented a higher, more inflated, and therefore greater dimension of the upper trunk.

VARIABILITY FINDINGS

The results from variability analyses are included partly in Table 2 and partly in Table 3. Columns 3 and 4 of Table 2 describe the 5 ratio distributions in terms of their standard deviations and their minimum and maximum values. Each standard deviation epitomizes in a single number the dispersion of one of the distributions. Inclusion of the lowest and highest ratios is incidental, serving only as a record of the two extreme values in each series.

As projected, variability was studied not solely to characterize the scatter of each distribution, but also to construct frames of

TABLE 3

FRAMES OF REFERENCE FOR 5 ANTHROPOMETRIC RATIOS ON BOYS 15 YEARS OF AGE: CATEGORIES ESTABLISHED BY THE PERCENTILE-DISTANCE METHOD, USING DATA ON 102 WHITE PUBLIC SCHOOL BOYS

Ratio	Low Ratio	Moderately Low Ratio	Average Ratio	Moderately High Ratio	High Ratio
$\frac{\text{Arm Girth} \times 100}{\text{Upper Limb Length}}$	Below 31.0	31.0— 32.5	32.6— 36.6	36.7— 39.7	Above 39.7
$\frac{\text{Chest Girth} \times 100}{\text{Stem Length}}$	Below 85.0	85.0— 88.0	88.1— 92.8	92.9— 98.3	Above 98.3
$\frac{\text{Leg Girth} \times 100}{\text{Lower Limb Length}}$	Below 38.4	38.4— 40.8	40.9— 44.2	44.3— 47.6	Above 47.6
$\frac{\text{Shoulder Width} \times 100}{\text{Hip Width}}$	Below 127.0	127.0—135.2	135.3—143.3	143.4—148.9	Above 148.9
$\frac{\text{Chest Girth} \times 100}{\text{Abdomen Girth}}$	Below 99.7	99.7—102.9	103.0—108.1	108.2—111.9	Above 111.9

reference useful in obtaining body form profiles on individual boys.[8] The choice of a method for the second purpose was conditioned by the fact that the ratio distributions were not all of one type, *i.e.*, not all comparable from the standpoints of skewness and kurtosis. In deference to this finding, frames of reference were developed in terms of percentile distances rather than standard deviation units.

Four percentiles were used to subdivide each distribution of ratios into 5 adjoining segments serially designated Low, Moderately Low, Average, Moderately High, and High. The percentiles selected were the 10th, 30th, 70th, and 90th. The 10th percentile provided the lower limit of the "Moderately Low" segment, the 30th and 70th percentiles supplied boundary values for the "Average" segment, and the 90th percentile served as the upper limit of the "Moderately High" segment.

The obtained frames of reference are presented in Table 3. The way in which this table describes the dispersion of the study sample in each of the 5 ratios follows from its method of construction. The "Low Ratio" category includes the lowest 10 per cent of the values in each distribution, the category captioned "Moderately Low Ratio" includes the next 20 per cent, the "Average Ratio" category encompasses the middle 40 per cent, the category captioned "Moderately High Ratio" comprises the next 20 per cent, and the "High Ratio" category encompasses the highest 10 per cent.

Use of the table as an aid in describing the body form of individual boys (*i.e.*, use as a vehicle in obtaining metrically based form profiles) is best illustrated by means of the actual ratio values for two of the subjects. Subject 39 has values of 30.2 per cent for the upper extremity ratio, 91.1 per cent for the body stem ratio, 38.8 per cent for the lower extremity ratio, 151.2 per cent for the shoulders-pelvis ratio, and 112.4 per cent for the thorax-abdomen ratio. Reference to Table 3 shows that he has slender upper limbs, an average body stem, moderately slender lower limbs, and a high predominance of upper trunk over lower trunk. Listed in like order, the ratios of Subject 71 are 41.5, 95.7, 46.2, 138.1 and 100.8. This boy will be

[8]The ratios of this study are not regarded as supplying more than part of what could be considered a reasonably comprehensive profile of body form. To these should be added ratios depicting head width in relation to head length, face width in relation to face height, chest depth in relation to chest width, upper limb length in relation to lower limb length, stem length in relation to length of the extremities, and possibly others.

seen to have stocky upper limbs, moderately stocky body stem and lower limbs, an average relationship between shoulder width and hip width, and a moderately small chest girth relative to his abdomen girth.

Correlation Findings

Associations among the 5 ratios were studied for the purpose of discovering which aspects of form vary independently, which show concomitant variation, and what orders of relationship exist. A particularly high association between 2 ratios, direct or inverse, would indicate the possibility of using one instead of both, thereby shortening the process of body form characterization.

The Pearson product-moment method of correlation was applied to the 10 scatter diagrams secured from all pairings of the 5 ratios that were possible. Table 4 presents the coefficients obtained, together with estimates of their statistical significance. It will be seen that,

1. A moderately high positive relationship exists between the ratio for the upper extremity and the ratio for the lower extremity. Other studies of these 2 slender-to-stocky variables have reported coefficients at ages 6, 7, 8, and 10 years ranging from .65 to .83 (12, 13, 14).

2. Positive associations of decreasing order are found for the body stem ratio with the upper limb ratio, the body stem ratio with the lower limb ratio, and the shoulders-pelvis ratio with the thorax-abdomen ratio. Comparable coefficients for ages 6 to 10 years confirm this gradation from moderate positive to low positive correlation (12, 13, 14).[9]

3. There is a low negative relationship between stockiness of the lower extremities and predominance of thorax over abdomen, *i.e.*, a slight inverse association exists for the ratio of leg girth to lower limb length and the ratio of chest girth to abdomen girth. A similar finding, reliable at the 5 per cent level of significance, holds in the case of chest girth $\times$ 100/stem length and chest girth $\times$ 100/abdomen girth.

4. The 3 coefficients for the shoulders-pelvis ratio with the slender-to-stocky ratios of the major body segments do not differ significantly from zero. That is, variation in shoulder width $\times$ 100/hip width—

[9]The *r*'s obtained in these studies fall between .42 and .66 for stockiness of stem and upper limb, between .26 and .53 for stockiness of stem and lower limb, and between .18 and .32 for predominance of shoulder width and chest girth.

TABLE 4

RELATIONSHIPS AMONG 5 ASPECTS OF BODY FORM: CORRELATION COEFFICIENTS AND ESTIMATES OF SIGNIFICANCE DERIVED FROM RATIO DATA ON 102 WHITE BOYS 15 YEARS OF AGE

	Arm Girth x 100 / Upper Limb Length		Chest Girth x 100 / Stem Length		Shoulder Width x 100 / Hip Width		Chest Girth x 100 / Abdomen Girth	
	r	*t**	*r*	*t*	*r*	*t*	*r*	*t*
Leg Girth x 100 / Lower Limb Length	.85	16.3	.58	7.2	—.03	0.3	—.34	3.6
Arm Girth x 100 / Upper Limb Length			.68	9.3	—.03	0.3	—.13	1.3
Chest Girth x 100 / Stem Length					.02	0.2	—.22	2.4
Shoulder Width x 100 / Hip Width							.37	4.0

* $t = r\sqrt{N-2}/\sqrt{1-r^2}$. All values above 2.6 indicate significance at the 1 per cent level.

among white boys 15 years of age—is independent of variation in the girth × 100/length ratios for the stem and extremities.

It follows that the 5 ratios investigated play distinctive roles in the characterization of body form. Each one adds to the form profile of an individual some information that is not derivable from knowledge of the others.

Summary

Study is made of 3 ratios depicting stockiness of the body stem and extremities, and 2 ratios portraying predominance of the upper trunk (thorax and shoulders) over the lower trunk (abdomen and pelvis). Problems of reliability, central tendency, variability, and intercorrelation are considered.

The sample consists of 102 white boys between the ages of 14 years 9 months and 15 years 3 months. It was drawn in the spring of 1950 from the public school population of School District No. 4, Eugene, Oregon.

Reliability analyses show that ratios derived from single measurements on a boy are less reliable than those derived from composite measures secured by two-man teams. Coefficients for the latter are all above $r = .95$.

The distribution of each ratio is described with reference to its mean, standard deviation, range, and 5 specified percentiles. Since some of the distributions are symmetrical and others skewed, the percentile-distance method is used in the development of a procedure for obtaining metrically based body form profiles on individual boys.

Associations are positive among the 3 ratios of the slender-to-stocky variety, negative between these ratios and the ratio for predominance of thorax over abdomen, and around zero for the ratio of shoulder width to hip width and the 3 stockiness ratios. Intercorrelations range from $r = +.85$ to $r = -.34$.

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TISSUE LYSIS BY SPLENIC PREPARATIONS

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The results of numerous studies have been reported describing the effect on living cells produced by various substances of a chemical or a biological nature, including splenic preparations from homologous and heterologous tissues. The possible value of these substances in the treatment of neoplasms has led to some interesting observations on their specific cytological effects.

Cameron, Kensler and Chambers (1946) showed that when human mammary carcinoma cultures were exposed for 24 hours to a concentration of .002M solution of heptanal sodium bisulphite methyl salicylate which was followed by a return to normal medium they underwent slow progressive and complete disintegration in four to five days.

Fell and Allsopp (1948) found that exposure of chick embryo cultures to low concentrations of mustard gas vapor caused slow death of the cells with softening and disintegration of the cytoplasm, and distortion of the cell outline, of the chromosomes in mitotic cells, and of the chromatin structure of resting nuclei. Sub-lethal concentrations produced many abnormal mitotic figures.

Amersbach, Walter and Sperti (1946) reported on 21 cases of basal cell carcinoma treated by injection of spleen or liver extract. Fourteen cases showed complete regression, 6 cases showed some regression, and only one case treated with spleen extract failed to regress.

Macfarlane, Schmock and Nadeau (1948) stored suspensions of dbrB tumors in a deproteinized extract of beef spleen at a temperature of 5°C. and reported a disappearance of cell division, a reduction in the size of the nucleoli and heterochromatic segments. There was an increase in the number of vacuolated nuclei and the destruction of chromatic material leading to pyknosis and hollow nuclear membranes.

Diller and Watson (1949) reported that injection of calves' spleen extract produced degeneration of cells of Sarcoma 37 in mice and

also of methylcholanthrene induced tumors in A strain mice. Cell changes consisted of vacuolization of the cytoplasm, nuclear pyknosis, or granulation and coagulation of the chromatin. Undamaged cells became greatly enlarged and polyploidy in these cells was unusually frequent. Normal tissue cells were unaffected, but there was mitotic stimulation in the blood forming organs.

Fardon, Prince and Berning (1948) made subcutaneous injections of beef spleen preparations into *dbA* mice which resulted in reduced mitotic activity in the crypts of Lieberkühn in normal animals.

The investigations in this report deal with a comparison of the effect of storage of normal and tumor tissues in normal nutrient and spleen preparations.

Materials and Methods

The tissues employed in this experiment were obtained from

(1) liver, kidney, and spleen of adult normal and tumor bearing white Rockland mice, and from normal dbA mice,
(2) liver of a 12-day chick embryo, and
(3) Sarcoma 180 as grown in Rockland mice.

All tissues used were removed and maintained under aseptic conditions as far as possible.

Three types of media were used.

(1) Normal nutrient medium, composed of
50% Simm's Serum Ultrafiltrate from Ox Serum
16 2/3% Isotonic (1.4%) $NaHCO_3$ Soln.
33 1/3% Tyrode's Soln. with four times the normal amount of glucose.

(2) Raw Aqueous Spleen Extract
Four spleens of normal healthy Rockland mice were excised and macerated through a stainless steel gauze and mixed with 26 cc. of normal medium. After shaking this suspension for a few minutes, it was frozen in an ice-salt mixture, thawed, and centrifuged.

(3) Whole Spleen Pulp
Two spleens of normal Rockland female mice were removed and macerated to a homogenous non-cellular emulsion. To this 20 cc. of Parker's medium were added. After freezing in the ice-salt mixture, the suspension was mixed and 2 cc. were used for culture medium in each flask.

The tissues were cut into fragments of about 1 cu. mm. and 10

pieces of each tissue were put into each of 3 sets of 50 cc. conical flasks which contained the three types of media.

The pH of the media was adjusted to 7.2 by a gas mixture composed of

O_2—80%
N_2—17%
CO_2— 3%

The flasks were capped and incubated at 37°C. Each day the flasks were opened and a fragment removed and fixed in Bouin's solution and later sectioned and stained with haematoxylin and eosin for comparison of the whole series with the original fresh tissue. At the same time the pH was adjusted by bubbling in the gas mixture for one minute.

Since the object was to exhaust the viability of the tissues completely, no fresh medium was added.

Observations

Comparative observations were made of changes in cytoplasm and nuclei. Counts of cells were also made to establish ratios between viable and dead cells, based on the degree of degeneration. A succession of premortal and necrotic changes, which were recognized, were used as criteria for dying and dead cells. These were manifested in the cytoplasm first by a hydropic swelling followed by irregular shrinking away from the region of the nucleus and cell membrane with vacuolization. This was followed by the development of intercellular spaces, the rupture of the cell membranes, and the total loss of the tissue pattern.

Nuclear degeneration followed two possible routes. One was to hypertrophy; the nuclei became three or four times normal size and then fragmented in karyorrhexis. The other was to atrophy; the nuclei developed small crenations on the surface, the chromatin network coagulated into a dense shrunken pyknotic knot, leaving a clear halo around the periphery of the nucleus. Chromatolysis followed, producing ghost nuclei. Horseshoe and doughnut-shaped nuclei were also encountered.

It was hoped that mitotic figures would help in the final analysis, but too few were encountered to be of any value. Nuclear division evidently occurred with impeded spindle formation and fission failure resulting in numerous double and triple nucleated cells, many poly-

ploid nuclei, and multi-nucleate cells containing many dark-staining nuclei.

A preponderance of nuclei near the periphery in sections of chick embryo liver may indicate cell division in that region or a migration of cells toward the surface of the explant.

The reaction times of the tissues to the various media is given briefly in the following paragraphs and in Table 1. The storage time

TABLE 1

RELATIVE VIABILITY OF VARIOUS TISSUES IN THE THREE TYPES OF MEDIUM AT 37°C.

Animal & Tissue	Parker's Medium		Medium with Spleen Extract		Medium with Spleen Pulp	
	½ life	Total Degeneration	½ life	Total Degeneration	½ life	Total Degeneration
Normal Rockland Mouse						
Spleen	7	10+	3	5	2	3
Kidney	2	7	2	5	2	3
Liver	4	7	3	5	2	5
Tumor-Bearing Rockland Mouse						
Spleen	5	7	2	4	2	5
Kidney	2	5	2	3	2	4
Liver	3	7	2	3	2	3
S-180	3	5	1	2	1	2
Normal *dbA* Mouse						
Spleen	7	10+	1	2	1	3
Kidney	2	4	1	2	1	2
Liver	4	7	2	3	2	3
12-day Chick Embryo Liver	2	5	1	3	1	4

when approximately half of the cells of the tissue appeared to have begun degenerative changes shall hereafter be referred to as the half-life period of the tissues.

Spleen. Spleen tissue of normal Rockland and *dbA* mice in normal Parker's medium showed slow degeneration. Half-life period was not reached until the seventh day. Spleen tissue of tumor-bearing Rockland mice showed less viability; it reached half-life period at five days and total degeneration at seven days. Spleen preparations more than doubled the rate of degeneration in normal Rockland and Rockland tumor-bearing spleen tissues, and accelerated even more in spleen of *dbA* normal mice.

Kidney. The rate of degeneration was rapid but more constant, and half-life period was only two days or less. The endothelial cells of the glomeruli survived longest, even after the tubular cells had degenerated. Spleen preparations had a limited effect on the kidney tissues of Rockland mice of both normal and tumor types, but as in spleen they hastened lytic processes in *dbA* kidney tissue.

Liver. Normal adult liver tissue showed slower degeneration in normal Parker's medium than the tumor liver tissue, but the latter had a longer half-life than chick embryo liver tissue. Spleen preparations accelerated degeneration in liver cells of normal *dbA* a little more than of tumor-bearing Rockland mice and chick embryo.

Tumor. The rate of degeneration was tripled when spleen preparations were used.

The figures indicate time in days. Where some viable cells were to be found in the tissues on termination of the experiment at 10 days, the time is given as 10+ days.

Discussion

The observed changes in tumor tissue stored in media containing splenic preparation resemble those described by Macfarlane, Schmock, and Nadeau (1948) at 5°C. and by Diller and Watson (1949) in vivo. Similar changes were observed in normal tissue stored in the same way, but they proceeded at a slower rate.

Ponder (1944) confirmed the findings by Maegraith, Martin, and Findlay (1943) of a lytic agent in a variety of human and animal tissues which produced lysis of red blood corpuscles. Maximum lysis occurred at a pH 7-1, and was much reduced at pH 6.5 and 8.0. A latent period of 12 hours led Ponder to deduce that the lytic substance was derived from precursors in the tissues. These agents were not specific for any species. He suggested that this agent may be lysolecithin and that it probably exists as a normal intervascular lysin, produced by many tissues and not spleen alone.

Similar lytic effects at a pH of 7.2 were noted in these experiments. However, the lytic properties of Rockland mouse spleen preparation appear to accelerate slightly the lysis of tissues of the *dbA* strain mice.

The very rapid rate of degeneration of fifty percent of the cells of the tissues and the reduced rate for the remaining cells agrees with the results of Niven (1929). He found that in treatment of mouse tissue cultures with a cytotoxic mouse anti-serum obtained

from rabbit, when weak-acting serum was used, the cells died after several hours and autolysis occurred; where strong serum was used, cellular death was rapid but subsequent autolysis was inhibited. The reduced activity may perhaps be due to the gradual exhaustion of the stores of the lytic agent or by its inactivation. Cytotoxic action was most rapid at 37.5°C.

The apparently diminished resistance to lysis of tissues of the tumor-bearing mouse invites further investigation. It would be of interest to learn how far-reaching the influence of the sarcoma-180 on other tissues may be, or what deleterious or weakening effect it exercises on them.

The tumor cells themselves appear to exhibit either a greater permeability to the lysins or to possess a weak protective mechanism against their lytic activity.

Summary

1. Tissue fragments of spleen, kidney, and liver of normal Rockland, sarcoma-180 tumor-bearing Rockland, and *dbA* mice, also of sarcoma-180 tumor and 12-day chick embryo liver, were stored at 37°C. in vitro in normal Parker's medium and media containing Rockland spleen extract and Rockland spleen pulp.

2. The splenic preparations produced an agent which acted as a lysin. They accelerated cytolytic changes in all tissues; however, little difference in the relative activity of spleen extract and spleen pulp was observed.

3. Rate of degeneration was rapid for the first 48 hours and usually half the cells succumbed. Thereafter it began to lessen.

4. The maximum sensitivity to the lytic effects of Rockland splenic preparation was shown by sarcoma 180 and most resistance by tissues of normal Rockland mouse.

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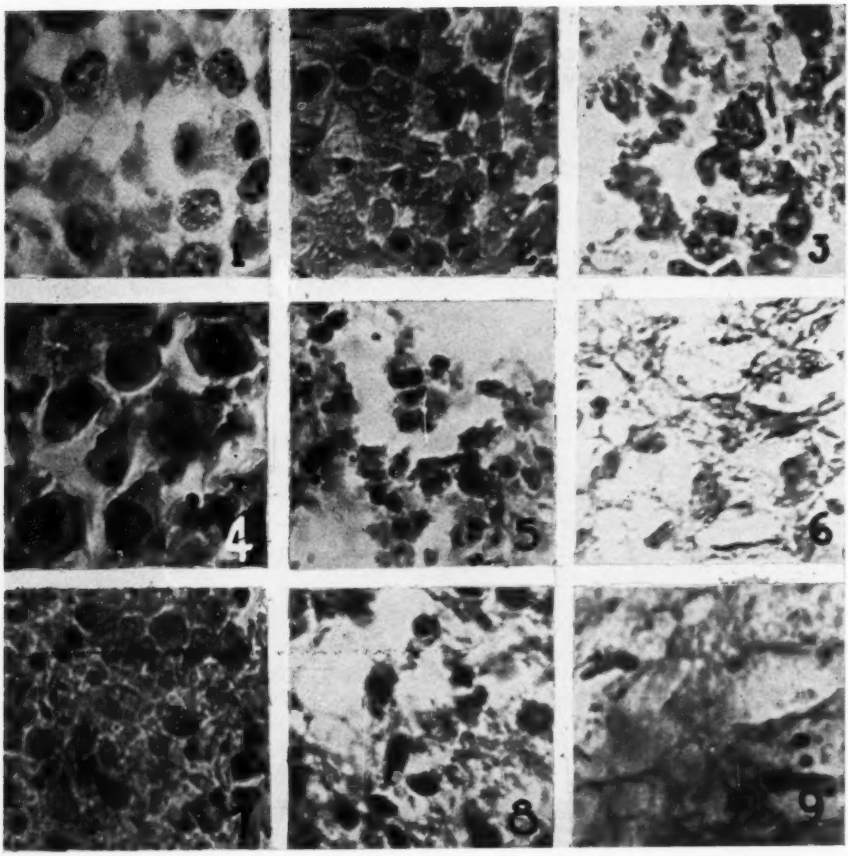
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PLATE I

Sarcoma 180 in Parker's Medium

Photograph 1. 24 hours, showing two cells in mitosis. (x1500)
Photograph 2. 48 hours. Some pyknotic nuclei and some disintegration of cytoplasm. (x645)
Photograph 3. 72 hours. Much agglutination of chromatin in nuclei. (x1500)

Sarcoma 180 in Spleen Extract

Photograph 4. 25 hours. Numerous nuclei arrested in metaphase. Much pyknosis and development of intercellular spaces. (x1500)
Photograph 5. 48 hours. Much cytolysis. Nuclei are all pyknotic and no longer appear viable. (x645)
Photograph 6. 72 hours. Cellular pattern totally destroyed. (x1500)

Sarcoma 180 in Spleen Pulp

Photograph 7. 24 hours. Much lysis of cytoplasm. (x645)
Photograph 8. 48 hours. Nuclei are all pyknotic. Cytoplasm is gone. (x645)
Photograph 9. 72 hours. No evidence of cell structure remaining. (x1500)

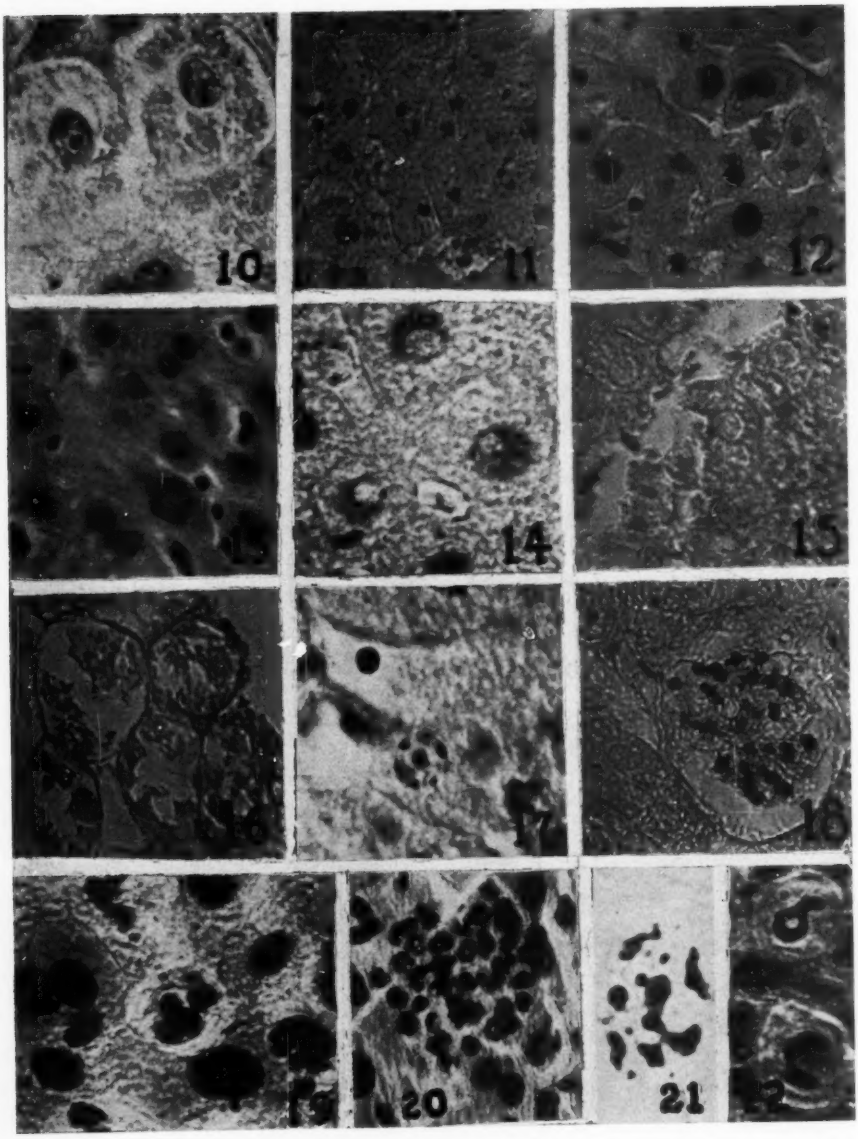
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PLATE II

Photograph 10. Liver, normal Rockland mouse, 24 hours in Parker's medium, showing swelling of cytoplasm. (x1500)

Photograph 11. Liver, normal Rockland mouse, 48 hours in Parker's medium, showing development of intercellular spaces. (x645)

Photograph 12. Liver, normal Rockland mouse, 48 hours in spleen extract, showing binucleated cells, swollen and vacuolated nuclei, and intercellular spaces. (x645)

Photograph 13. Liver, dba mouse, 48 hours in spleen extract, showing swelling and vacuolization of nuclei and intercellular spaces. (x645)

Photograph 14. Liver, normal Rockland mouse, 48 hours in spleen extract, showing three vacuolated nuclei. (x1500)

Photograph 15. Liver, normal Rockland mouse, 96 hours in spleen extract, showing "ghost" nuclei. Contents of nuclei has undergone lysis. (x645)

Photograph 16. Kidney, normal dba mouse, 96 hours in spleen extract. Only the stroma about the tubules is intact. (x645)

Photograph 17. Kidney, normal Rockland mouse, 48 hours in Parker's medium, showing pyknosis and fragmentation of nuclei. (x1500)

Photograph 18. Kidney, normal Rockland mouse, 72 hours in Parker's medium. Only glomerular nuclei remain visible. (x645)

Special Nuclear Effects

Photograph 19. Liver, normal Rockland mouse, 24 hours in spleen extract. Numerous giant nuclei and multinucleated cells. (x1500)

Photograph 20. Liver, normal Rockland mouse, 24 hours in spleen extract, showing a cluster of small horseshoe and doughnut-shaped nuclei. (x645)

Photograph 21. Single fragmented nuclei of normal Rockland liver cell, 48 hours in spleen extract. (x1500 and enlarged)

Photograph 22. Two bizarre nuclei from normal Rockland liver after 48 hours in spleen extract. (x1500)

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REGENERATION OF SPINES BY SEA URCHINS OF THE GENUS *STRONGYLOCENTROTUS*

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INTRODUCTION

Even a brief perusal of Mortensen's "Monograph of the Echinoidea" (1928, 1935, 1940, 1943a, 1943b, hereafter referred to as Mortensen's Monograph) causes one to realize the significance attached by taxonomists to the structure of the spines of the echinoids. Deutler's (1926) searching study of the growth of the sea urchin skeleton causes one to wonder if the age of some species might not be determined by the study of transverse sections of the spines. There are, however, in the literature a number of accounts of the loss of these structures and their subsequent regeneration. Przibram (1904, pp. 1291-1293) has summarized the data on regeneration published prior to his writing, and Mortensen's Monograph includes within the species accounts references to practically all the published reports on the subject and presents a number of original observations. Chadwick (1929) reports a case of the loss of all spines by an *Echinus esculentus* and their subsequent regeneration. No mention of the process as occurring in the genus *Strongylocentrotus* has come to the writer's attention, but both Mortensen (Monograph) and Cuénot (1948, p. 149) appear to consider regeneration of spines general among the echinoids.

Thus, it is aimed in the present work to determine

1.) whether members of the genus *Strongylocentrotus* will regenerate lost spines;

2.) whether such spines would have the same number of radial wedges (often referred to by taxonomists) as the original spines; and

3.) whether such spines would show the original number of cycles (concentric circles of differentiated structure, reminding one of growth rings in trees) in cross section.

The writer wishes to express his appreciation for financial aid to this investigation from the state of Washington funds for medical and biological research.

Materials and Methods

The specimens studied were collected intertidally on the shores of San Juan Island, Washington (State), on November 2, 1951, and belonged to the species *Strongylocentrotus droebachiensis* (O. F. Müller), *S. purpuratus* (Stimpson) and *S. franciscanus* (A. Agassiz).

On the following day spines, as indicated below, were removed from a large *S. droebachiensis* (hereafter called "large *S. d.*"), a small *S. droebachiensis* ("small *S. d.*"), a single *S. purpuratus* ("*S. p.*"), a small *S. franciscanus* ("small *S. f.*") and a large *S. franciscanus*.

After the removal of the spines the animals were suspended to the bottom of the bay from the face of the Laboratory dock in a wooden box (2′ long, 1′ wide, and 1′ high) with one-half inch mesh galvanized screening over the top and bottom. At the beginning and one month later a considerable quantity of the large brown alga *Nereocystis luetkeana* (Mertens) Post. and Rupr. was placed in the box for food. Shortly the large *S. franciscanus* died and on November 9th was replaced by another, which is the specimen hereafter called "large *S. f.*"

Sixty days later the specimens were removed from the box, reexamined, and such spines as had regenerated sufficiently for ready handling were removed. This period was thus from Nov. 3, 1951, to Jan. 2, 1952, for all except the large *S. f.* for which it extended from Nov. 9, 1951, to Jan. 8, 1952. Throughout this period daily sea water temperatures at approximately one meter below the surface were taken from the Laboratory's observation pier, about 1/4 mile from the dock. Because of the strong tidal currents and high degree of mixing of the water, there is to be expected little difference in water temperature between the two places, nor is the difference between the bottom and one meter below the surface expected to be appreciable (cf. Phifer and Thompson, 1937), especially at this season. Throughout these periods the water temperature was almost steadily dropping. On Nov. 3, it was 9.1°C. and had dropped to 7.1°C. by Jan. 2 with an average of the daily readings being 8.3°C. On Nov. 9, it was 9.0°C. and had dropped to 6.9°C. by Jan. 8, with an average of 8.1°C.

Throughout this paper Lovén's (1874) system of numbering the

radii is used. This system has been described by Grant and Hertlein (1938, pp. 139-143), Jackson (1912, pp. 32-34) and on pp. 21-22 of Volume 2 of Mortensen's Monograph. For convenience of work the plates in the radii are numbered beginning next to the apical system rather than at the peristome.

From each animal the chief primary spine of each plate in radius 2A was removed except for one plate at the ambitus. This spine was left as a marker. As an additional marker and in order to have data on the ambital spines, the spine or spines from the adjacent plate or plates in radius 2B were removed at the ambitus. The removal of a spine was accomplished by firmly grasping the spine near its base with forceps, breaking away the tissues of the capsule between the base of the spine and the tubercle with a needle and pulling the spine loose.

Both the original spines and the regenerated spines were measured in length to the nearest half millimeter, cut in two within two millimeters above the milled ring or shoulder of the base of the spine with a safety razor blade, placed in 5.25 per cent sodium hypochlorite (full strength "Chlorox" or "Purex") for a few minutes and washed in tap water. Then the cut surface was examined by reflected light with the aid of a dissecting microscope magnifying 45 diameters. In this manner the number of wedges and cycles (when present) were counted. The work was greatly facilitated by holding the spines in small pieces of plasticine, both for examination and filing, and by marking the edge of one of the wedges with a very sharp pencil. The number of wedges recorded is the number at the edge of the cross section. In some instances, thru bifurcation or independent addition between wedges, new ones are added from the center outward. More rarely the number decreases from the center outward thru the reverse processes. These changes are most frequent in *S. franciscanus* and in the spines near the peristome.

Discussion and Conclusions

A new spine was regenerated on nearly every tubercle from which one had been removed. Except for the large *S. f.* these new spines were large enough to be removed and examined.

The numerical data are summarized in Table 1.

In no case did the regenerated spine have the same number of

TABLE 1. DATA ON REGENERATION OF SPINES BY SEA URCHINS OF THE GENUS *STRONGYLOCENTROTUS*

Approximate Test Size	Small *S. franciscanus*						*S. purpuratus*						Large *S. droebachiensis*				Small *S. droebachiensis*			
Original:	Diam. 53mm.			Ht. 23mm.			Diam. 70mm.			Ht. 34mm.			Diam. 78mm.		Ht. 40mm.		Diam. 35mm.		Ht. 22.5 mm.	
Final:	Diam. 54mm.			Ht. 24mm.			Diam. 70mm.			Ht. 34mm.			Diam. 78mm.		Ht. 40mm.		Diam. 39.5mm.		Ht. 20.5 ?mm.	
Original Spine No.	*Wedges* Orig.	Regen.	*Cycles* Orig.	*Length* Orig.	Regen.		*Wedges* Orig.	Regen.	*Cycles* Orig.	*Length* Orig.	Regen.		*Wedges* Orig.	Regen.	*Length* Orig.	Regen.	*Wedges* Orig.	Regen.	*Length* Orig.	Regen.
↑ Apex		(73)			2mm.			(43)			6mm.							(25)		4mm.
1	70	74	1	8mm.	3½		46	42	2	10mm.	3		26	33	7½mm.	2½mm.	27	28	3½mm.	5
2	67	66	3	18½	3		46	47	2	13½	3		(33)	(0)	6½B	0	26	28	5½	5
3	67	65	4	25	2		52	41	3	13	3½		25	33	14½	2½	25	26	4½B	5
4	62	66	6	33	2½		52	41	3	11½	2		28	39	15	2½	23	31	7	5
5	58	70	6	34½	3		48	45	2	11½	3		25	36	7½B	2½	24	29	7	4½
6	2B6 52	66	7	30½	2½		49	46	2	16	2½		28	36	12½	2½	22	30	6B	5
	2B7 50	67	7	24½B	2½															
7	46	62	5	24	1½		(46)	(—)	2	15½	1½		31	33	15	2½	22	29	8	5
8	39	53	5	18½	2½		2B8 45	49	3	15½	3		32	36	9B	2	2B8 20	31	10	5
																	2B9 21	28	9½	4½
9	29	48	4	13½	2		48	40	2	8	4		2B9 24	36	10B	3				
													2B10 24	31	14	2½	21	28	9½	5
10	25	46	3	11½	3		47	38	2	11½	4		25	36	12	2½	19	27	7½	5
11	25	38	3	10	4		42	32	2	11	3½		22	31	12½	2½	18	28	7½	4½
12	30	37	2	9½	4½		38	32	2	9	3		25	30	10B	2½	17	22	6½	5
13	*22*	31	2	8	4		33	34	2	2B	3½		24	33	12½	2	15	23	5	5
14		(*19*)			3½		38	32	2	8	4		24	31	10½	2½	13	23	5½	5
15							34	30	2&1	7	1½		22	30	11	3	*11*	10	2	5
16							30	26	2&1	7½	4½		21	34	11	2½		(*8*)		2½
17							26	19	1	8	1½		18	36	9½	2½				
18							*21*	*19*	1	7	4		16	32	3½B	2½				
19													19	29	8½	3				
20													*15*	25	5½	3				
← Peristome														(*15*)		2				
Average	45.9	56.4					40.9	36.1					23.7	33.0			20.3	26.3		

Notes: The letter "B" indicates that an appreciable portion has obviously been broken off.

Figures in parentheses not used in determining averages.

wedges as the original. For the two specimens of *S. droebachiensis* studied the numbers of wedges in the new spines were, with few exceptions, considerably greater than in the original spines. This is especially interesting in view of the observations in Mortensen's Monograph (vol. 3, pt. 3, p. 207) to the effect that specimens living in the ebb-zone have shorter and more robust spines than specimens living in deeper water, and that the forms with short, robust spines have more numerous wedges than those with more slender spines. One wonders if the intertidal specimen doesn't lose more spines than the one living in the quieter depths and thus have a larger proportion of regenerated spines.

The new spines produced by the *S. purpuratus* had with three exceptions fewer wedges than the original spines. The small *S. franciscanus* regenerated spines which averaged more than ten wedges greater than the original spines.

Although the regenerated spines of the large *S. franciscanus* were too small (with three exceptions well under one millimeter in length) for examination, and although the data on this specimen are not included in Table 1, a few comments concerning it may be justified. Its test was approximately 130 mm. in diameter and 61 mm. high. Radius 2A consisted of 19 plates. The spines (substituting 2B8 and 2B9 for 2A9) averaged 63.3 wedges with a range of 42-74. The number of cycles per spine ranged from 2-11 with no obvious correlation of number of cycles to position of the plate in the radius. Although the spines removed at the beginning of the experiment were of normal size, several of them had the non-cyclic meshwork centers such as are illustrated in Figures 76 and 178, vol. 3, part 2 and Figure 21, vol. 3, part 3 of Mortensen's Monograph as regenerated spines of species of other genera.

The original spines of *S. droebachiensis* did not show readily discernible cycles, and thus number of cycles is not recorded for that species in the table. Except for spines between the apex and the ambitus of the small *S. droebachiensis,* the regenerated spines in cross-section showed a large central area of irregular meshwork surrounded by superficial wedges which extended inward scarcely beyond the external ridges, which in these species are directly continuous with the wedges (cf. pp. 50, 51 Mortensen's Monograph vol. 3, pt. 2.). In none of the regenerated spines of any of the species were cycles

present. The wedges of the apical spines of the small *S. droebachiensis* extended nearly to the center of the spines. One wonders if cycles would have been apparent had this specimen belonged to a species having them, and if the wedges of the spines of the other specimens would with additional growth have extended inward thru a reorganization of the inner meshwork.

Incidental Observations

In the course of this work the following items were noted beyond the original aims:

1.) In the table two of the original spines of *S. purpuratus* near its peristome are recorded as having 2 and 1 cycles. This refers to the fact that on one side of the spine two cycles were clearly marked, but that as these cycles were followed to the other side they merge into one. The same phenomenon was noticed in two of the spines near the peristome of the large *S. franciscanus*.

2.) Rate of spine regeneration, on the basis of this limited evidence, would appear to be inversely related within a species to the size and age of the specimen.

3.) The regenerated spines of the *S. purpuratus* are purple, not green as are the spines of a young specimen of this species. One of the writer's students, Miss Patricia F. Knight, has noticed that the central core of the externally purple spines of large *S. purpuratus* remains greenish in color. This causes one to wonder if evidence cannot be obtained as to whether the spines of the fine-spined *S. purpuratus* often seen (Clark, 1948, p. 280) may or may not be regenerated spines. Chadwick (1929) suggests this explanation for the fine-spined *Echinus esculentus*. An examination of six interambulacral ambital spines from each of two such fine-spined *S. purpuratus* (with test diameters of ca. 75 and 96 mm.) reveals no greenish core and for the smaller specimen only one cycle and for the larger two cycles. The writer does not consider this complete proof that these spines are regenerated, but along with the fact that examination of these specimens with the aid of a dissecting microscope reveals a considerable number of spines obviously in early stages of regeneration, he thinks the suggestion is strong. It may be worthy of mention that of the three species considered *S. purpuratus* has the greatest preference

for areas of rough water and has the heaviest and toughest shell, characteristics which might make it most subject to abrasion and at the same time best fitted for survival if it were torn loose from its footing and washed over the rocks in the surf. This species, however, adheres to the rocks with extreme tenacity and moves little. This tendency against much movement may result in its remaining where conditions for its life are temporarily very poor. Hobson (1930) has clearly observed that conditions unfavorable for the life of *Psammechinus* may cause their loss of spines.

4.) One possible objection to the above tentative hypothesis lies in the fact that the denuded tests of such small-spined specimens have smaller than normal tubercles. Hence, the experimental animals except for the large *S. f.*, which is being held alive for further developments, were sacrificed and the tests cleaned. Examination reveals that the balls at the tips of the tubercles from which the original spines had been removed were visibly and appreciably smaller than tubercles at comparable positions in other radii, as though the tubercles had decreased in size to fit the new small spines. These balls also lacked their usual pearly lustre. Below the ambitus on the *S. purpuratus* many of these tubercles had become smaller than those of the normally smaller primary spines at either side of the plate. The reduction in size of tubercle was obvious on all four specimens, but probably the most marked on the *S. franciscanus*. Between the apex and the ambitus of the large *S. droebachiensis* the tubercle of one of the secondary spines on each of several plates from which the chief primary had been removed was much larger than normal, as though the removal of the primary had stimulated its growth.

5.) As can be seen from the table, there is a tendency for the original spines from some point above the ambitus to have the largest number of wedges and a gradual reduction in the number of wedges per spine toward the peristome. The writer has noted this on other specimens of these species and on a deep water white form that occurs locally, which is probably *S. echinoides* (A. Agassiz and H. L. Clark) (cf. pp. 219-222, vol. 3, pt. 3 of Mortensen's Monograph). This tendency is scarcely discernible in a series of specimens considered to be *S. droebachiensis* from the vicinity of Point Barrow, Alaska, furnished the writer thru the courtesy of Dr. Ira L. Wiggins

of the Arctic Research Laboratory. These last may belong to the species *S. pallidus* (G. O. Sars) (cf. Vasseur 1952).

6.) Another point obvious from the table is that several of the specimens apparently had added plates, some at the apical end of the radii and others next to the peristome. There is no doubt about the additions next the apex, and while the writer felt fairly confident that he removed and counted the spines all the way to the peristome at the beginning of the experiment, the addition of new plates there surprised him so much that the literature was surveyed and new experiments were begun. Since this paper was originally submitted, these experiments have been completed and verify all the findings here reported except for the addition of coronal plates next to the peristome.

7.) In the writer's attempts to find reliable characters upon which to separate the above mentioned deep water white urchin from *S. droebachiensis*, he has examined the outer edges of the wedges of the spines (magnified 100 diameters) and frequently found those of the white form to be smooth whereas those of typical *S. droebachiensis* were serrate. Examination of the regenerated spines of all four specimens revealed them to be much more strongly serrate than the original spines and especially so toward the tips of the spines. The strong serration of these regenerated spines reminds one of the condition existing in very young metamorphosed *S. droebachiensis* as illustrated by Agassiz (1872-'74, Plate X).

Summary

An experiment has been performed, the results of which strongly suggest that

1. Spines regenerated by sea urchins of the genus *Strongylocentrotus* do not have the same number of wedges or cycles as the original spines;

2. That these differences may be great enough to be of value in explaining certain variations between different populations of sea urchins;

3. That the rate of spine regeneration is inversely related within a species to the size and age of the specimen;

4. That the small-spined specimens of *S. purpuratus* may be in-

dividuals which thru the vicissitudes of their environment have lost their spines and are regenerating new ones;

5. That the removal of spines may induce changes to occur in the tubercles upon which they rested and changes in the rate of growth of neighboring spines and tubercles;

6. That within a given radius one of the spines between the ambitus and the apex has the largest number of wedges and that between that spine and the peristome there is a gradual reduction in number of wedges per spine; and

7. That at least while regeneration is still in progress the regenerated spines are more strongly serrate than the original spines.

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Growth, 1952, **16**, 37-41.

AN INDIRECT PROOF FOR THE TOLERANCE THEORY OF VITAMIN FUNCTION

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The Tolerance Theory of Vitamin Function explains the role of vitamins as consisting essentially in a combination of the vitamin with the apo-enzyme which makes the apo-enzyme tolerant to its own products without preventing its enzyme function. As a result, the enzyme continues to function for a longer time, because it is not so easily retarded by the accumulation of its own products. Thereby, the cells obtain available energy for a longer time, and this enables them to multiply to larger numbers. It has been shown (Growth V. 15:267-287) that *Lactobacillus casei*, which requires riboflavin for full development, is prevented from reproduction by addition of small amounts of lactic acid if grown *without* riboflavin, whereas cells cultivated *with* riboflavin are capable of reproduction in the acid medium. It has also been shown that the Old Process yeast which is used for the assay of thiamine, dies in a good medium with 7.5% alcohol when grown without thiamine, but multiplies with that same amount of alcohol when thiamine is present.

The general description of vitamins as growthfactors is not wrong, but it puts the emphasis on a secondary function. The actual vitamin function is the protection of the enzyme, and this protection yields a longer continuation of energy utilization for growth.

The definition of vitamins as co-enzymes is not wrong either, as long as this term merely implies that they are a necessary part of efficient enzyme action. The word "co-enzyme" does not imply anything else; it does not give any explanation whatever as to why or how the vitamin assists the enzyme.

If riboflavin makes the cells of *Lactobacillus casei* tolerant to acid, this vitamin should have hardly any effect in a medium containing $Ca\ CO_3$ because the acid would be neutralized as soon as it leaves the cell, and there would be no need for protection against H ions. A slight stimulative effect should still be noticeable for there will

be protection *within* the cell where the acid is produced, whereas the carbonate, being but slightly soluble, can protect only against the acid that has diffused out of the cell. As $CaCO_3$ makes the medium slightly alkaline (pH 6.8) the development of the cultures is at first retarded. *Lactobacillus plantarum* is even more sensitive to alkalinity than *Lactobacillus casei* and very definitely requires a slightly acid medium for good development (R. Zemgalis, 1952, J. Bacteriology . . . in print).

The earlier experiments (GROWTH V. 15:267-287) had shown that *Lactobacillus casei* multiplies in the regular assay medium at about equal rates with and without the vitamin until measurable amounts of acid have been produced. From then on, the culture with vitamin, being protected against the harmful effect of the lactic acid, surpasses the control culture without riboflavin in number of cells as well as in quantity of acid produced.

Table 1 shows the effect of the carbonate on the number of bacteria developing in assay medium with and without riboflavin. The ratio of cells grown with vitamins to cells grown without it increases greatly without carbonate, indicating the great protection brought about by the vitamin. When carbonate is added, this ratio decreases, the difference becoming smaller because the vitamin is not needed so urgently. The decrease of the ratio $\frac{\text{with vitamin}}{\text{without vitamin}}$, from 317 without $CaCO_3$ to 131 with 0.3% and to 16 with 1% carbonate, shows very clearly that the protection against acid is an important function of the vitamin.

The graph shows a slower increase with carbonate, i.e., a retardation of the growthrate, caused by the slight alkalinity of the $Ca\ CO_3$. Without carbonate, the growth curves without and with the vitamin are practically alike for the first thirty-one hours. At this time, the cells have multiplied to about a million per ml, and sufficient acid is produced by them to retard the growth rate of the cells without vitamin, but not of those with the vitamin. When 1% Carbonate is added, this event becomes noticeable only after forty-eight hours. The neutralizing effect of the $Ca\ CO_3$ makes the protection by the vitamin unnecessary for the first forty-eight hours.

TABLE 1

NUMBER OF CELLS (COLONY PLATE COUNT) OF *Lactobacillus Casei* IN DIFCO ASSAY MEDIUM

	No Carbonate					0.3% Carbonate					1.% Carbonate				
	Vitamin		No Vitamin		Ratio + cells / 0 cells	Vitamin		No Vitamin		Ratio + cells / 0 cells	Vitamin		No Vitamin		Ratio + cells / 0 cells
Hrs.	cells	pH	cells	pH		cells	pH	cells	pH		cells	pH	cells	pH	
0	2,200	6.5	2,270	6.5	1:1	2,200	6.5	2,270		1:1	2,200	6.5	2,270	6.5	1:1
8	3,600	6.5	3,700	6.5	1:1	3,400	6.8	3,350	6.8	1:1	2,900	6.8	3,100	6.8	1:1
22	97,000	6.2	82,500	6.4	1.2:1	20,000	6.8	20,200	6.8	1:1	16,100	6.8	19,100	6.8	0.8:1
31	1,020,000	6.0	936,000	6.4	1.1:1	125,000	6.8	182,000	6.8	0.7:1	96,000	6.8	100,000	6.8	0.96:1
48	75,000,000	6.0	3,650,000	6.2	20.8:1	1,750,000	6.8	1,750,000	6.8	1.2:1	1,050,000	6.8	1,125,000	6.8	0.94:1
72	156,000,000	5.7	3,150,000	6.2	50.0:1	45,000,000	6.8	1,370,000	6.8	3.3:1	16,000,000	6.8	1,600,000	6.8	10.0:1
168	570,000,000	4.5	1,800,000	6.1	317.0:1	230,000,000	5.8	1,750,000	6.6	131.2:1	170,000,000	6.4	10,700,000	6.8	16.4:1

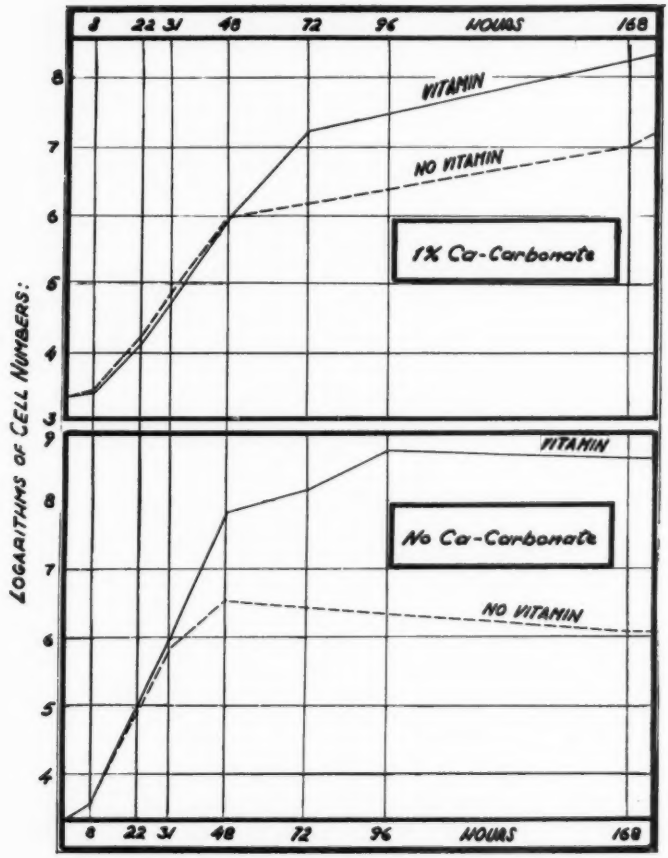

FIGURE 1
The decrease of the Efficiency of Riboflavin by the Addition of Calcium Carbonate.

SUMMARY

The theory that vitamins protect a cell against its own metabolic products could be proved indirectly with *Lactobacillus casei* which requires riboflavin for abundant multiplication and acid production. In the standard assay medium, the addition of the vitamin had little effect when Ca CO_3 was present to neutralize the lactic acid. Without

carbonate, the addition of vitamin increased the bacterial population 317 times. With 0.3% Ca CO_3, this increase was 131 times, and with 1% Ca CO_3, it was only 16 times.

A slight effect of the vitamin must be expected to remain because the acid is formed within the cell while the insoluble Ca CO_3 neutralizes only the acid that diffuses out of the cell. The results support the tolerance theory of vitamin function.

Growth, 1952, **16**, 43-45.

THE FUNCTION OF NIACIN EXPLAINED BY THE TOLERANCE THEORY

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Previous experiments (Growth, V. 15:267-287) had shown that the essential function of three vitamins (riboflavin, thiamine, and ascorbic acid) was due to the same basic reaction: the cells became more tolerant to their own metabolic products. The following experiment shows that this explanation of vitamin function also applies to a fourth vitamin, namely niacin.

To three bottles with 100 ml of the Difco niacin assay medium, graded amounts of lactic acid—0.9%, 1.2%, and 1.5%—were added. A parallel set for each batch was supplied with 2 ppm niacin. All bottles were inoculated from a one day old culture of *Lactobacillus plantarum;* the bottles without niacin were inoculated from a culture grown in a niacin-free medium, the niacin-containing bottles from a culture grown in niacin-supplemented medium.

The experiment was carried out at room temperature (average 25°C).

Table 1 and the corresponding graphs show the effect of added acid on cultures with and without niacin. Since *Lactobacillus plantarum* likes an acid medium, both cultures grow almost equally well in a medium with 0.9% lactic acid. The niacin-containing cultures outnumber the niacin-free cultures only slightly, and vitamin pro-

TABLE 1

Growth of *Lactobacillus plantarum* in Assay Medium, with Added Lactic Acid, With and Without Niacin

Time in Hours	0.9% lactic acid		1.2% lactic acid		1.5% lactic acid	
	Niacin	0	Niacin	0	Niacin	0
0	15,000	2,200	13,700	2,030	14,200	2,000
3	15,900	1,950	14,300	1,750	13,600	1,230
6	16,100	1,910	15,300	2,000	14,100	517
12	16,150	2,580	14,700	744	12,400	201
24	39,700	2,000	14,800	442	12,700	48
48	410,000	21,500	24,100	138	8,800	1
72	2,550,000	190,000	40,300	115	6,940	0
148	343,000,000	16,900,000	240,000	35	2	

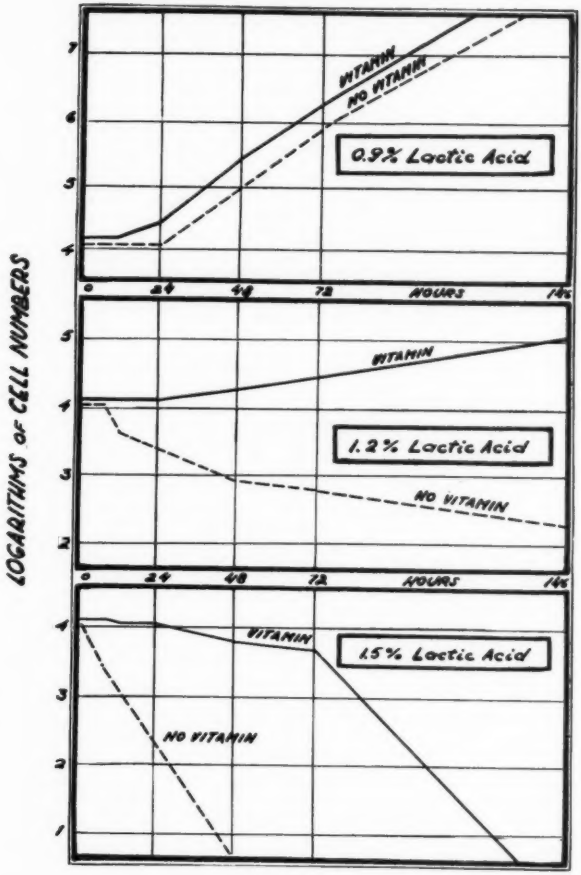

FIGURE 1

The Effect of Niacin on Growth and Death of *Lactobacillus plantarum* in a Medium to which various amounts of Lactic acid had been added.

tection against this acidity is hardly noticeable. With 1.2% lactic acid the protection by vitamin becomes quite obvious: the niacin-fed cells still multiply although at a decreased rate, whereas the cells without niacin gradually die. With 1.5% lactic acid, both cultures die, but the difference between the death rates is remarkable: the

vitamin-fed cells die in 148 hours, while the vitamin-starved cells die in 48 hours.

Summary

Cultures of *Lactobacillus plantarum* grown in a niacin-rich medium which contained graded amounts of added lactic acid were compared with parallel cultures grown without niacin. In every case the vitamin-fed cells outnumbered the vitamin-starved cells which apparently were not able to tolerate the same acidity in the same degree. This proves that niacin exerts a specific function in protecting *Lactobacillus plantarum* against lactic acid, the normal metabolic product of the cell.

Growth, 1952, **16**, 47-54.

THE PRENATAL GROWTH OF THE DOG SPLEEN

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Some years ago a study similar to this was made on the development of the spleen in the fetal cat (Latimer, '40). The prenatal growth of the spleen has been reported for man by Jackson ('09) and for the pig by Lowrey ('11). There seems to be but very little data on the size of the spleen during the prenatal period, and not as much on the postnatal growth of this organ as is available for many other organs. Some of the earlier literature has been given in the paper on the cat spleen and will not be repeated here. Since that time there have been several studies on the postnatal growth and size of the spleen in man and in other animals.

Krumbhaar ('42) presents data on the size of the human spleen from 300 cases and reviews the earlier work on the human spleen. Webster, Liljegren and Zimmer ('47) have studied the spleen weight in adult rats, and a similar study for the spleen weights in the guinea pig has been made by Webster and Liljegren ('49). All of these papers agree on one thing, namely, the variability in weight of the spleen. Some of this may be due to two things, first, the irregular pulsation of the smooth musculature found in the walls of the spleen causing a variation in size, and also the fact that the spleen is not purely a lymphoid organ, but it contains a variable amount of blood as well as the splenic corpuscles. There is, apparently, no quantitative data on the dog spleen or its growth during the fetal period.

MATERIALS AND METHODS

Since the first study of these fetal and newborn dogs was published (Latimer and Corder, '48), 71 additional fetuses have been added to the series and for this study the spleens were taken from 187 fetal and 24 newborn dogs. The details of the material and the methods are given in this first paper and additional data concerning the litters is given in a more recent paper (Latimer, '50b). The spleens were removed with the other organs, kept in a moist chamber until

weighed in glass stoppered weighing bottles on an analytical balance sensitive to 0.1 mg. All fat, blood vessels and mesenteries were cut close to the organ so that its weight is, as near as possible, that of the spleen alone. A few of the larger spleens were weighed only to the nearest milligram but most of them were weighed to 0.1 mg.

The curvilinear formulae were found by the method of trial and error, and the straight line formulae were found by the method of least squares (Snedecor, '38). The weight of each spleen as a percentage of the body weight was found and these percentages were treated as were the absolute weights in finding the formulae for the curves which were drawn for these percentages. The formulae based on body weight may be used only between 15 and 400 gm. of body weight and the formulae for estimating the spleen weight from body length are valid only from 75 to 250 mm. of body length. The average of the weights or percentage weights were found for each 10 gm. increase in body weight or each 10 mm. increase in body length. These averages were used in finding the formulae and also in determining the percentage deviation of the calculated from the observed values.

Weights in Milligrams and Percentage Weights

Figure 1 shows the weights in milligrams of the individual spleens plotted on body weight measured in grams in the line which rises more slowly at first and then rises to a higher level. Associated with this line are shown the weights of the individual specimens. The dots represent fetal males, the circles, fetal females, the dots enclosed by a circle newborn males and the double circles, newborn females.

This growth curve is best fitted by two formulae, the first an exponential formula and the second a first degree formula. From 15 to 118 gm. of body weight, the curve was drawn from the formula:

$Y = 0.025\ (X^{1.85})$, and from 118 to 400 grams of body weight the formula is:

$Y = 3.4\ X - 235.4.$

In both of these formulae, Y represents the weight of the spleen in milligrams and X, the body weight in grams.

The average percentage deviation of the calculated from the observed values for these two formulae is 8.70%. The average deviation

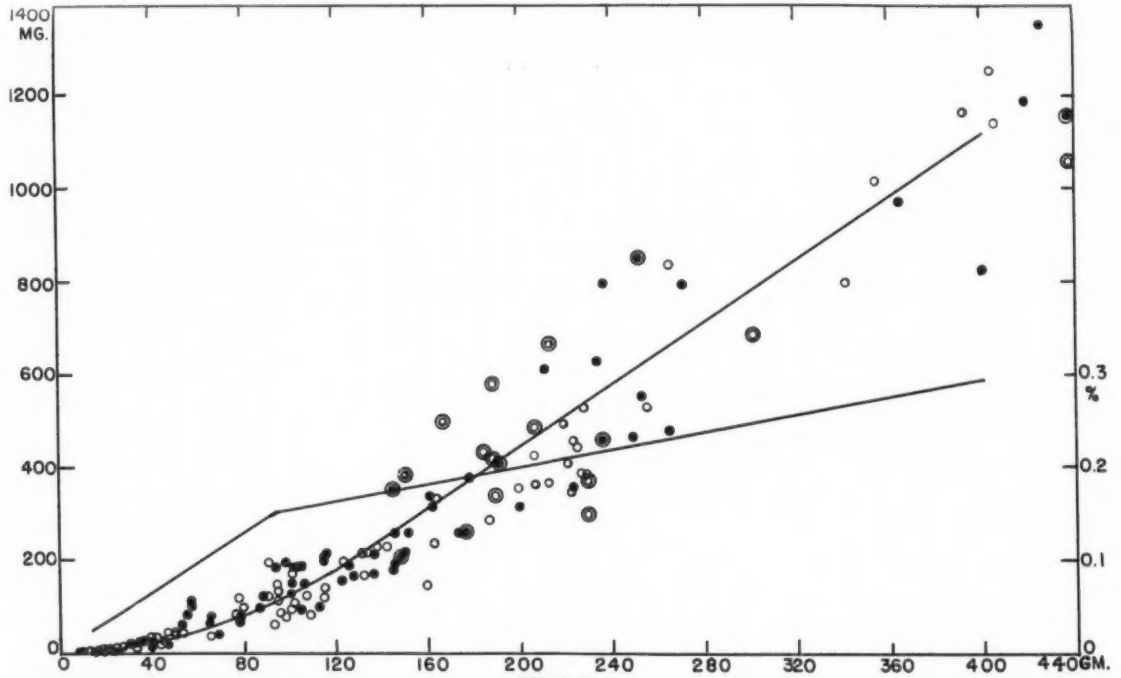

FIGURE 1

The weights of the spleen in milligrams plotted on body weight in grams is represented by the line rising slowly at first and with the individual cases. The dots represent fetal male spleens, the circles, female fetal spleens and the dots enclosed by a circle, newborn male spleens and the double circles, newborn females. The line without any cases and rising more rapidly at first and then falling below the line showing growth in milligrams, shows the changes in percentages of the spleen with reference to body weight. These percentages are given in the right margin. Empirical formulae are given in the text for both of these curves.

of the first is large, or 11.24% and the second is better fitted with an average percentage deviation of 4.95%.

The line in figure 1 without any cases and rising more rapidly at first and then falling below the other line at about 180 grams of body weight represents the weights of the spleens as percentages of the body weight. The scatter of these percentages was about the same as the absolute weights and to save space this line is shown in this figure without the individual percentages.

The formula from which this percentage curve was drawn from 15 to 90 gm. of body weight is:

$Y = 0.0012\ (X^{1.08})$, and from 90 to 400 grams of body weight:

$Y = 0.00046X + 0.1099$.

In these formulae Y represents the percentage weights of the spleens with reference to body weight and X, the body weights in grams. The average percentage deviation of the calculated from the observed values is 9.46% for the first part of the curve and 6.23% for the second formula. The average for all of the curve is 7.85%, or slightly less than for the absolute weights plotted on body weight.

The same spleen weights in milligrams plotted on body, or nose-anus length, measured in millimeters, are shown in figure 2. The dots, circles and dots enclosed by circles and double circles represent respectively, fetal males and females and newborn males and females as in figure 1. This curve was best fitted by two exponential formulae rather than one very complicated formula.

From 78 to 116 mm. of body length the formula for this curve is:

$Y = 0.00004\ (0.1X)^{5.5} - 0.89$, and from 116 to 250 mm. of body length:

$Y = 0.0033\ (0.1X)^{4} - 31.92$.

In the above formula Y represents the weight of the spleen in milligrams and X, the body or nose-anus length measured in millimeters. The average percentage deviation of the calculated from the observed values is 6.66%, with an average percentage deviation of 7.27 for the first formula and 6.40 for the second formula.

The percentages of the total body weight for each spleen were plotted on body length as was done for body weight and these were fitted with a formula. The curve drawn in figure 2 without any cases and rising more rapidly at first and then falling below the curve of

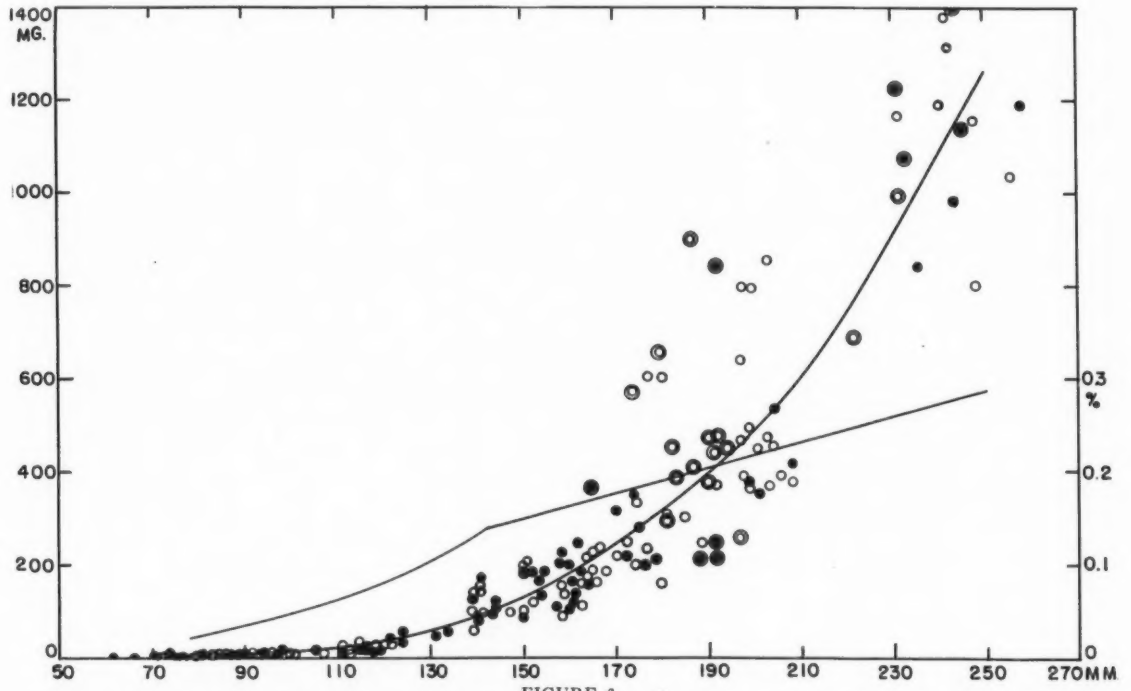

FIGURE 2

The weights of the spleen in milligrams are shown plotted on body length in millimeters. The same symbols are used for male and female fetuses and male and female newborn as in the preceding figure. The line without any cases and rising more rapidly at first and then falling below the other line, represents the percentages of the spleens. Empirical formulae are given in the text for both of these curves.

absolute weight above 190 mm. of body length represents the spleens as percentages of the body weight.

The first part of this curve was fitted with the following exponential formula from 75 to 142 mm. of body length:

$Y = 0.000017\ (0.1X)^{3.4}$ and from 142 to 250 mm. of body length:

$Y = 0.0014X - 0.0581.$

In both of the above formulae, Y represents the spleen as a percentage of the body weight and X, the nose-anus length measured in millimeters.

These two formulae fit the cases as well as any of the formulae, for the average percentage deviation of the calculated from the observed values is 7.04%. The average percentage deviation for the first formula is 8.76 and for the second 5.89%.

The individual cases are very crowded at the beginning of the curve when body weight in grams is used as the abscissa, and in figure 1 they are so close together that the marked variation is not as well shown as it was on the larger preliminary graphs. The smallest fetuses weighed only a little over 3 grams and the formulae for the curves based on body weight begin at 15 grams of body weight. Below this weight the formulae do not fit. The three gram fetus had a nose-anus length of 55 mm. and the formulae in figure 2 begin at 78 mm. for the absolute weight and 75 mm. for the percentage curve. These weights and percentage weights increase very slowly and also very irregularly when plotted on body or nose-anus length, or on the body weight.

The distribution of the males and females indicates no distinct sex difference in either the fetal or newborn dogs. The weights of the spleens of the newborn puppies are all well grouped with the weights of the spleens of the fetal dogs, when all of these spleen weights are plotted on either body weight or body length. Thus the formulae may be used for males or females or for newborn spleens.

During the early fetal growth the spleen is very small and its growth is very slow. The earlier paper on the spleen of the fetal cat (Latimer, '40) shows that it likewise grows very slowly and irregularly in the early fetal period. In the fetal cat the growth of the spleen follows the increase in body weight more closely than the increase in body length. There is not much difference in the dog, but if any difference the spleen weight tends to follow the body length slightly better.

TABLE 1
THE WEIGHTS OF THE SPLEEN AS PERCENTAGES OF THE BODY WEIGHT AND TOTAL INCREASE IN WEIGHT IN GRAMS

	Percentages at the beginning of fetal period	Percentage weights at birth	Total increase in weight in grams
Human spleen (Jackson, '09)	0.014	0.431	87,897 times
Pig spleen (Lowrey, '11)	0.016	0.17	1,555 times
Cat spleen (Latimer, '40)	0.07	2.25	689 times
Dog spleen	0.017	0.282	952 times

The percentage weights of the spleen for man, pig, cat and dog at the beginning of the fetal period and at the time of birth have been assembled in table 1. The cat spleen is relatively the heaviest throughout the entire fetal period. There is not much difference in the percentage weights of the other three spleens at the beginning of the fetal period but at time of birth the human spleen is the heaviest of the three followed by the dog spleen and the lightest of all, the pig spleen. The curves given by Lowrey seem to show that the prenatal growth of the spleen in the pig is more uniform throughout the entire fetal period. The others grow very slowly at first and then with an increasingly rapid rate in the later part of the fetal period.

The total increases of the weights in grams of these four spleens are shown in the last column of table 1. This is the increase from the beginning of the fetal period to birth. It is interesting to see how this total increase as a multiple of the initial weight follows the size of the newborn. The human newborn being the heaviest followed by the pig, then the dog and lightest of all the cat.

When anything unusual was observed in one of these fetuses a notation was made on the back of the data card when the fetus was dissected and the parts weighed. These records have been checked for data on the spleens. The spleen in the smallest specimens was an elongated thin, flat, ribbon-like structure. In the smaller specimens, or up to about 14 to 16 grams of body weight, it was clear and transparent and very thin. Then a darker or pinkish line, was seen traversing the long axis of the spleen. This looked like a band or "plume" of pinker color within the lighter or somewhat transparent spleen. Then around 26 gm. of body weight the entire spleen assumed a pinkish color but with a darker red axis. Above 38 gm. there are no records of this dual coloration. In the fetuses above this body weight the spleens were uniformly dark colored and opaque. At first they were not as dark colored as the livers. No histological

sections were made but judging from the gross appearance it seems that first the spleen contains but very little blood. In fact most of the internal organs in these smaller specimens are light in color. Then the darker color appears, first along the central axis and later filling the entire spleen.

There was only one accessory spleen found in this series, a small spherical mass dorsal to the spleen in the greater omentum, one spleen with the dorsal end bifurcated and a spleen, perfectly normal in gross appearance which had herniated under the left lateral lumbocostal arch into the thoracic cavity. These anomalies have been described together with the other anomalies found in this series of puppies in an earlier paper (Latimer, '50a), and will not be described further here.

Summary

Empirical formulae are given whereby the weight of the spleen in milligrams or as a percentage of the body weight may be computed from either the body weight in grams or the body length in millimeters.

The spleen of the fetal dog is variable in weight, as has been reported in other animals. It grows slowly at first and then more rapidly in the latter part of the fetal period.

The changes in gross appearance of the spleen are described. One accessory spleen, one with a slightly bifurcated tip and one spleen which had herniated into the thoracic cavity were found.

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BOOK REVIEWS

REVIEW OF TRANSACTIONS OF THE SECOND CONFERENCE ON THE ADRENAL CORTEX JOSIAH MACY, JR. FOUNDATION

This book is a record of conferences by a group of investigators interested in the adrenal cortex and its effects on metabolic reactions. The formal presentations are interrupted frequently by questions and discussions by members of the group. This makes for interesting reading and the overall effect is that of taking the reader into the conference room and providing him also with the stimulus of the questions and the discussion.

The first presentation, that of Dr. Choh Hao Li of the Department of Biochemistry of the University of California, concerned the status of the chemistry of ACTH. Dr. Li's report includes a complete amino acid analysis of ACTH protein by microbiological methods and chromatographic studies of peptides obtained by pepsin hydrolysis of ACTH protein. He has established that there are two types of active ACTH, one protein and the other peptide in nature. He suggests that that name ACTH should be reserved for the protein hormone and that the peptide should be called ACTIDE. In the discussion Dr. Astwood (Tufts Medical College, Department of Medicine) reported that he had also been engaged in studies on the purification of the protein ACTH and that he was able to increase the activity of the ACTH ten or fifteen fold following cellulose adsorption of the material and elution. He felt that the question of whether the hormone is protein or peptide in nature, has not been settled.

Professor George Sayers of the Department of Pharmacology at the University of Utah College of Medicine presented data on factors concerned with the regulation of adrenocorticotropic activity. Discussion on the presentation was apparently vehement and is extremely interesting.

A most provocative presentation was that of Dr. Thomas F. Dougherty of the Department of Anatomy of the University of Utah College of Medicine on the relation of the adrenocortical hormone to the hypersensitive state. Dr. Dougherty's presentation included a discussion of "inflammation" and brought the discussion back to some of the fundamental considerations of cellular situations and develop-

ment. One of his conclusions is that "adrenocortical secretions unquestionably have a marked antiphlogistic action on the inflammation produced by allergy". It was pointed out that "adrenalectomy notably increased the inflammatory response and that cortisone treatment profoundly decreased the cellular changes in inflammation".

There were two other reports: One on Hyaluronidase and the Adrenal Cortical Hormone by Dr. Jeannette Opsahl of the Department of Physiological Chemistry of Yale University School of Medicine and one Further Clinical Studies with ACTH and Adrenal Cortical Hormones by Dr. George W. Thorn of the Department of Medicine, Harvard Medical School.

These conferences, which include the discussions and ideas of all of the members of the group, not only provide a considerable amount of factual data but have the additional advantages of stimulating the reader and of providing more than one point of view on the subject.

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SENN, MILTON J. E., (ed.). "Symposium on the Healthy Personality". *Trans. Spec. Meetings of Conf. on Infancy and Childhood.* June 8-9, July 3-4, New York, 1950. Josiah Macy, Jr. Foundation. pp. 298 ($2.50).

Of special interest are "Growth and Crises of the Healthy Personality", by Erik H. Erikson (pp. 91-146) and "Constitutional and Prenatal Factors in Infant and Child Health", by M. F. Ashley Montagu. (pp. 148-175). Erikson differentiates between a "subjective sense of being healthy" and the "objective evidence of health" as determined by a physical examination. In the development of mental health the first component is "a sense of basic trust", the second "a sense of autonomous will", and the third "a sense of initiative". This sequence depends for its proper unfolding and realization upon the "conclusion that a child and even a baby—perhaps even the fetus—sensitively reflects the quality of the milieu in which he grows up". Accordingly, Erikson feels that "if we will only learn to let live, the plan for growth is all there."

Montagu defines *constitution* as "the sum total of the structural, functional, and psychological characters of the organism." It is, in

substance, genetic potential plus modifying environment. With respect to the former, the author says that "genes determine, not characters nor traits, but responses of the developing organism to the environment". There is a very useful summary on the problem of materno-fetal emotional relationships, discussed under the headings of physical agents, nutritional effects, drugs, infections, material dysfunction, maternal sensitization, and parity. Montagu concludes that "nothing whatever is known of the relation of body type to personality in infants, and it is more than doubtful if such a relation exists."

Both these papers are discussed at length in the book, and Montagu presents an extensive list of References.

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